IMAGE CONGEALING VIA EFFICIENT FEATURE SELECTION

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. application Ser. No. 13/346,479 entitled "Image Congealing Via Efficient Feature Selection," filed on Jan. 9, 2012, which is hereby incorporated by reference in its entirety.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH & DEVELOPMENT

This invention was made with Government support under grant number 2009-SQ-B9-K013 awarded by the National Institute of Justice. The Government has certain rights in the invention.

BACKGROUND

The present disclosure relates generally to image congealing, and more particularly, to a feature selection method for image congealing.

Group-wise image alignment, also known as "congealing", is a process of jointly estimating warping parameters for all images in an ensemble. There are many applications of image congealing. During the learning phase of an object detector, the position of the object (e.g., a face, pedestrian, or car) for training images can be automatically provided by congealing, rather than by being labeled manually. Congealing can improve appearance-based face recognition performance. For example, automatic labeling of facial landmarks can be enabled by semi-supervised congealing, which can also potentially be used to discover the non-rigid shape deformation of a real-world object.

DRAWINGS

These and other features, aspects, and advantages of the present technique will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

FIG. **1** is a schematic of an image alignment method including an unsupervised feature selection method and a congealing method in accordance with an embodiment of the present disclosure;

FIG. **2** is a table displaying results of an empirical study conducted with an unsupervised feature selection algorithm in accordance with an embodiment of the present disclosure;

FIGS. **3**A-**3**D are graphs illustrating experimental results comparing the performance of two previously described filter type algorithms with an unsupervised feature selection algorithm in accordance with an embodiment of the present disclosure;

FIGS. **4**A-**4**F are graphs illustrating experimental results comparing the performance of two previously described filter type algorithms with an unsupervised feature selection algorithm in accordance with an embodiment of the present disclosure;

FIG. **5** is a table displaying results of a comparison between a previously described filter type algorithm with an unsupervised feature selection algorithm in accordance with an embodiment of the present disclosure;

FIGS. **6**A-**6**D are graphs illustrating congealing accuracy and efficiency over various feature dimensions using a congealing algorithm having an unsupervised feature selection algorithm in accordance with an embodiment of the present disclosure;

FIG. **7** is an image ensemble comparing various average warped images before and after congealing with various feature selection dimensions in accordance with an embodiment of the present disclosure;

FIG. **8** is an image ensemble illustrating the locations of various selected features at different iterations using an unsupervised feature selection algorithm in accordance with an embodiment of the present disclosure; and

FIG. **9** is a method including an unsupervised feature selection algorithm which may be incorporated into a least-square-based congealing algorithm in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION

The goal of congealing is to estimate the warping parameters by iteratively minimizing a distance metric computed using the feature presentation of each image. In particular, there are three key elements to image congealing: cost function, optimization method, and feature representation. Certain methods utilize the mutual information as the cost function for optimization, while other methods employ a least-squared distance between image pairs in the ensemble. Regarding the optimization method, the gradient descent and the inverse compositional approach may also be used.

Existing methods may use original image intensities as the feature representation, which has a number of drawbacks. Since such representation usually resides in a high-dimensional space, it imposes a substantial computational burden for optimization, especially with a large image ensemble. Also, because many pixel intensities are redundant due to local proximity to their neighboring pixels, they may hinder the optimization process. To remedy this problem, as shown in FIG. **1**, the present techniques include an unsupervised feature selection approach to automatically choose a subset of feature representation and use the subset for image congealing. For example, by using only less than 3% of the original feature representation, both the accuracy and efficiency of congealing may be substantially improved compared to congealing without feature selection. In the illustrated embodiment, an unsupervised feature selection method **10** and congealing algorithm **12** may be applied to a blurred average image **14** to generate an aligned image **16**. Specifically, the unsupervised feature selection method **10** and the congealing algorithm **12** use selected features **18**, which are a subset of the total feature representation.

In addition to combining feature selection and congealing, the disclosed embodiments also include a novel unsupervised feature selection approach. In other words, the novel unsupervised feature selection may be incorporated with a congealing algorithm (e.g., a least-square-based congealing algorithm). Specifically, a graph having features as the vertices is generated, and the connectivity between the vertices is determined by a maximum information compression index. A simple and fast graph clustering method called power iteration clustering (PIC) is used to partition the graph into subsets and select a representative feature from each subset. As discussed in detail below, the disclosed method has significant advantages in efficiency, especially when the feature dimension is high, while achieving comparable effectiveness in terms of removing feature redundancy. Moreover, the proposed method can be applied to other learning tasks beyond congealing, due to its independence from the objective function and optimization algorithm for the target concept.